A New NASA Initiative in Three-Dimensional Tomographic Reconstruction of the Aerosol-Cloud Environment, 3D-TRACE: Outcome of a One Year Pilot Study

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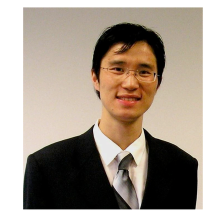






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3D-TRACE Vision:

Demonstrate that optical (VNIR) ***cloud and aerosol remote sensing*** can move ***beyond the horizontal uniformity assumption applied to each pixel.***

Old paradigm: "atmospheric column" retrievals based on *rigorous 1D radiative transfer (RT)* predicting observed signals

Why?

It is the only approach deemed practical in terms of computational efficiency.

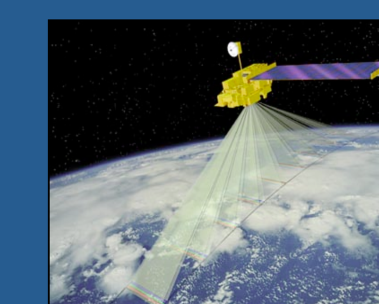
New paradigm: tomographic retrievals based on *approximate but fast 3D RT* to predict observed signals

How?

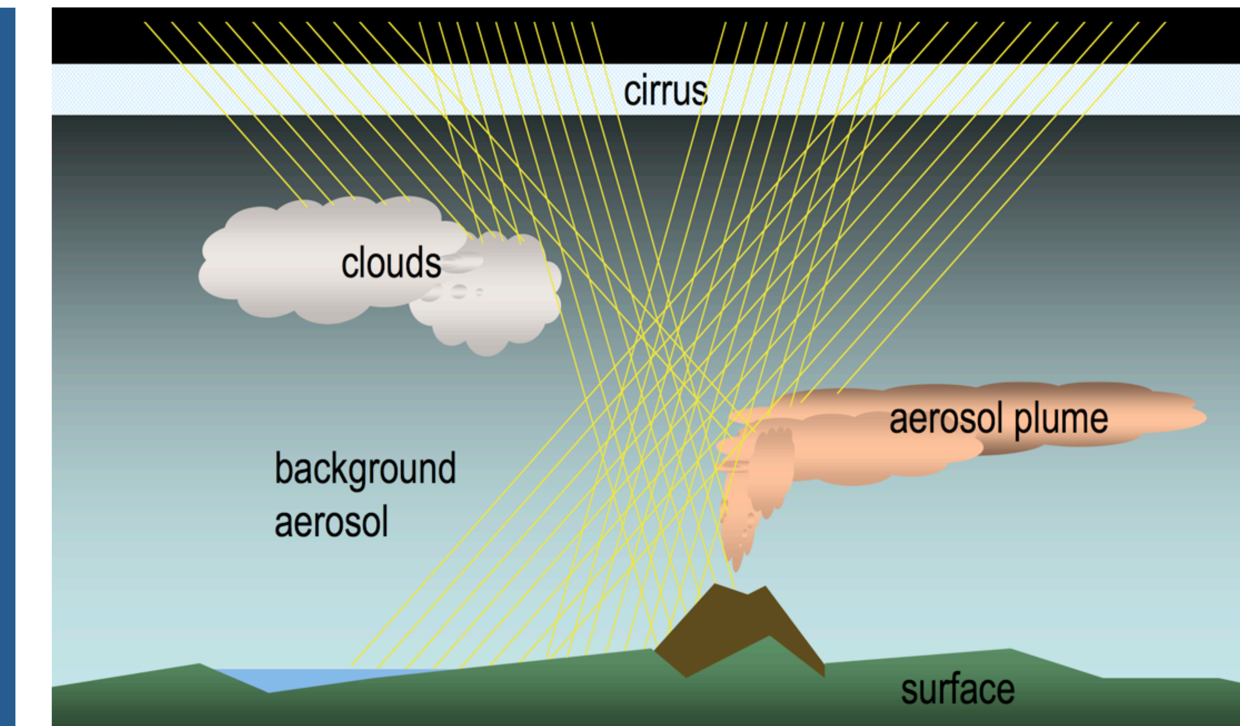
Computational technology has made quantum leaps.

Hardware: Moore's law, which will primarily help us generate high-fidelity 3D RT simulations (spatially realistic synthetic "data") for algorithm testing

Software: Capitalize on advances in tomographic methods and inverse problem solutions driven largely by medical science



MISR/Terra



3D-TRACE schematic: Spatially-resolved multi-angle views (yellow rays) intersect horizontally and vertically distributed elements of the scene, thus enabling 3D atmospheric tomography.

Objective

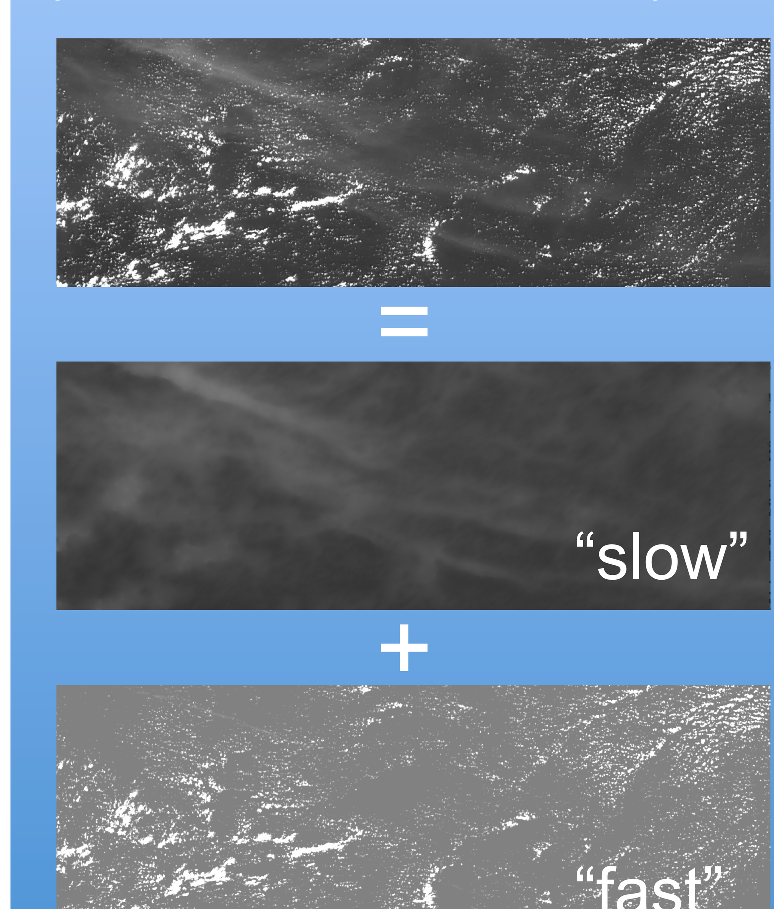
- Develop robust and efficient techniques for performing tomographic reconstruction of the 3D atmosphere, using remote sensing theory and satellite data, to more accurately represent complex aerosol-cloud interactions.
- Illustrate via 3D tomographic reconstructions of selected test scenes, both real (MISR) and synthetic with different levels of fidelity (ranging from parametric shapes to outputs of Large-Eddy Simulation models).
- Design and build a computational framework for developing and testing innovative **multi-angle/multi-pixel algorithms** (possibly with multi-spectral/multi-polarization elements as well).

Approach

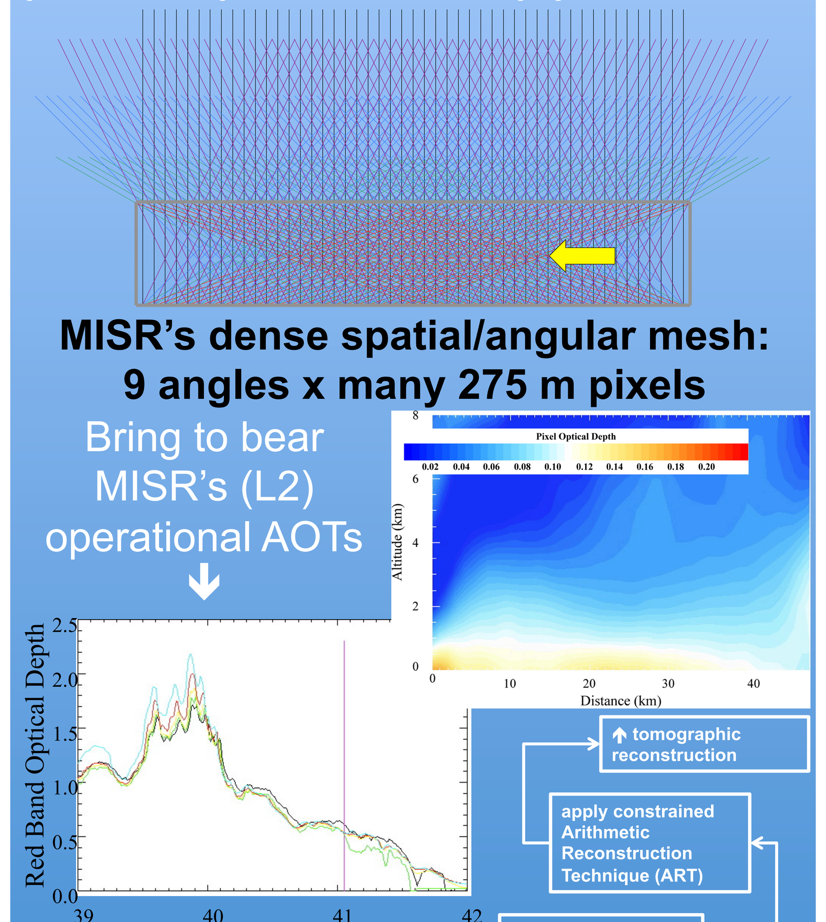
- Adapt and enhance spatial correlation methods from statistical image processing technology to separate radiances originating scene-wide from two distinct cloud/haze layers, e.g., cirrus (Ci) layer over broken cumulus (Cu).
- Use or adapt proven tomographic methods from biomedical imaging technology to infer 3D spatial structure of aerosol-dominated and mixed cloud-aerosol scenes.
- Exploit recent progress in computational 3D radiative transfer, including polarization, for synthetic **multi-pixel/-angle data** to support rigorous uncertainty quantification in 3D scene reconstruction.

ONE-YEAR PILOT STUDY: Proof of 3D-TRACE concept based on 1 + 2x(1+1) + 1 = 6 independent component-level demonstrations …

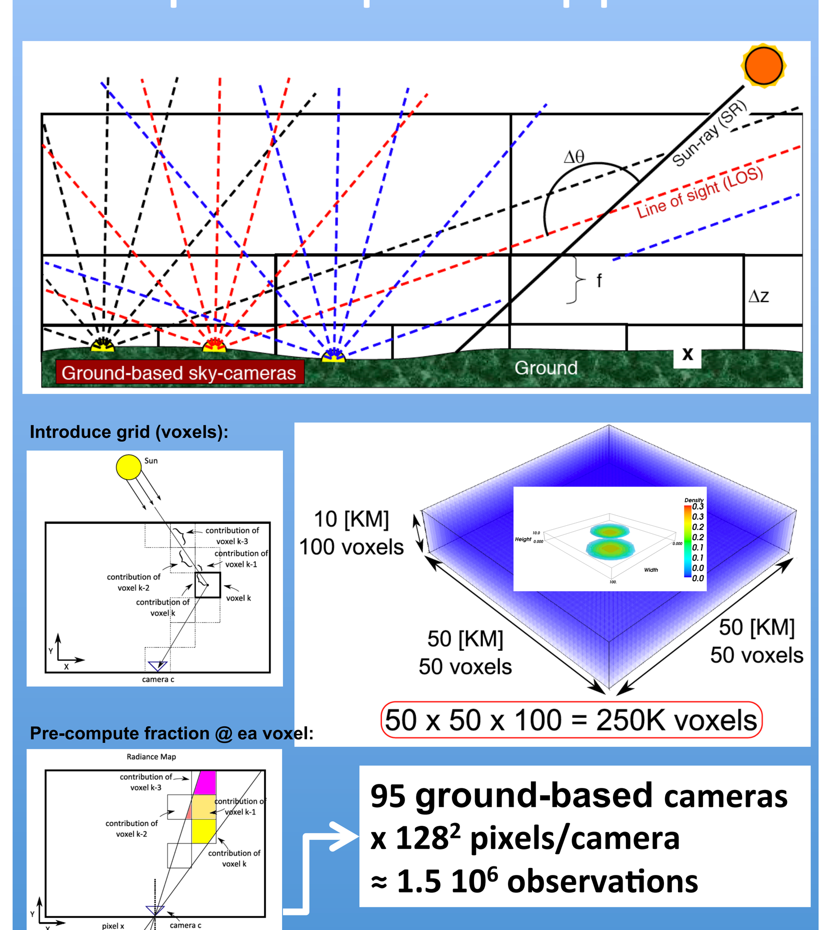
1. Separation of two distinct cloud layers using spatial scale variability



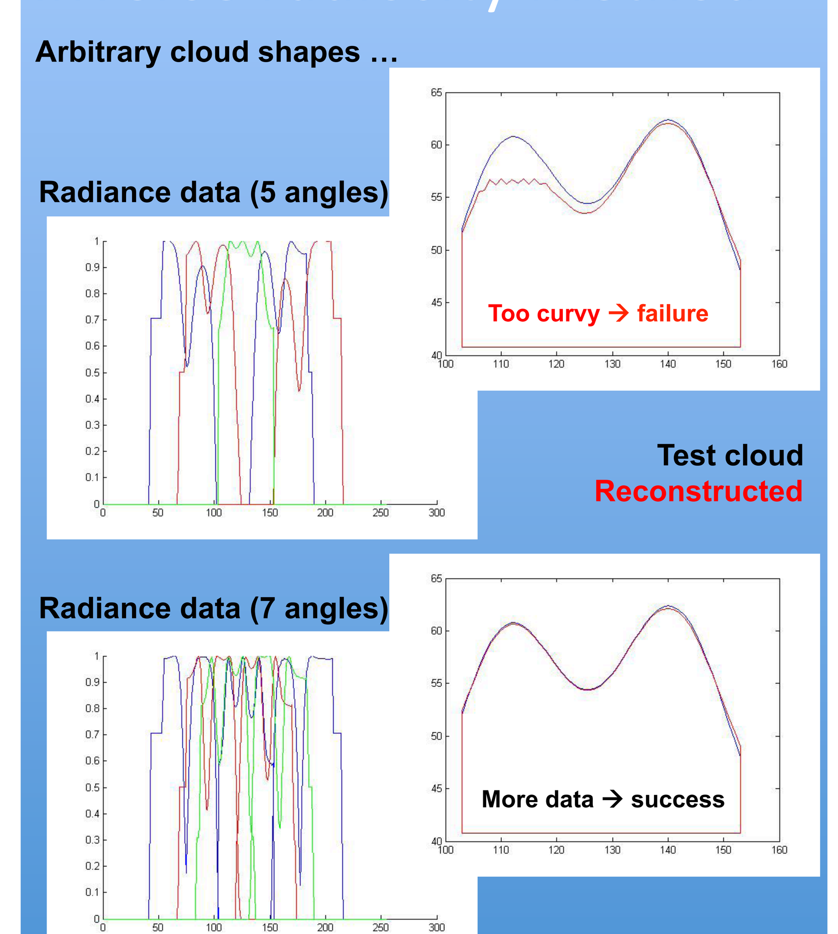
2a. Aerosol extinction field reconstruction, JPL's ill-posed problem approach



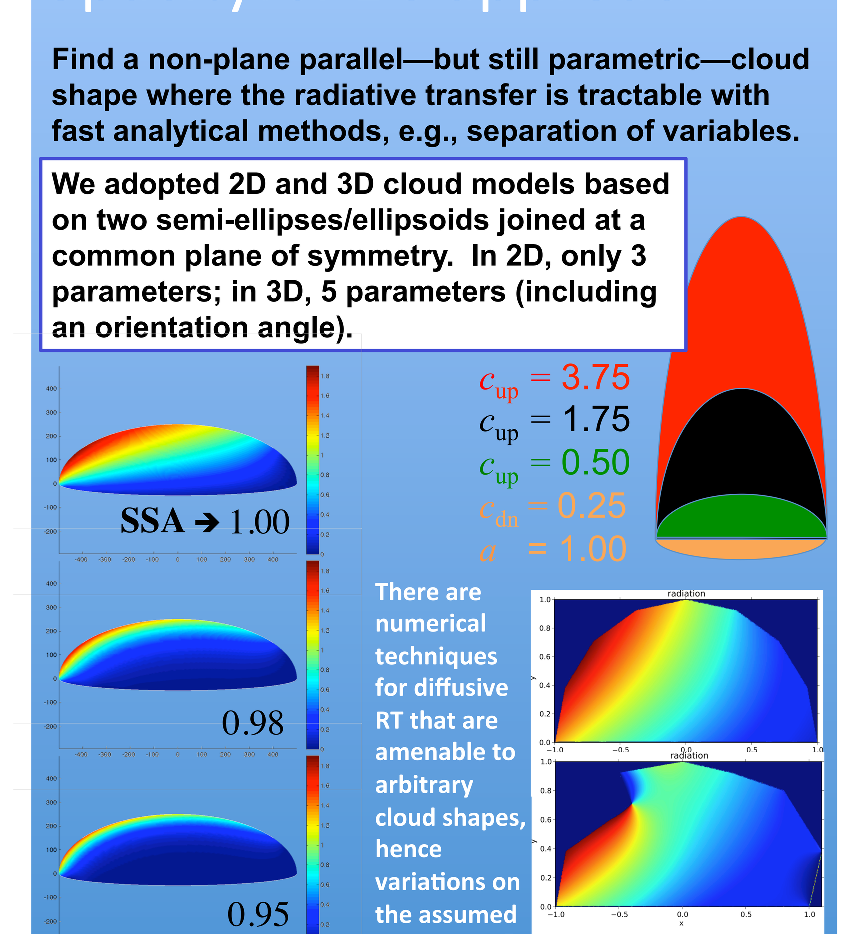
2b. Aerosol extinction field reconstruction, Technion's well-posed pblm approach



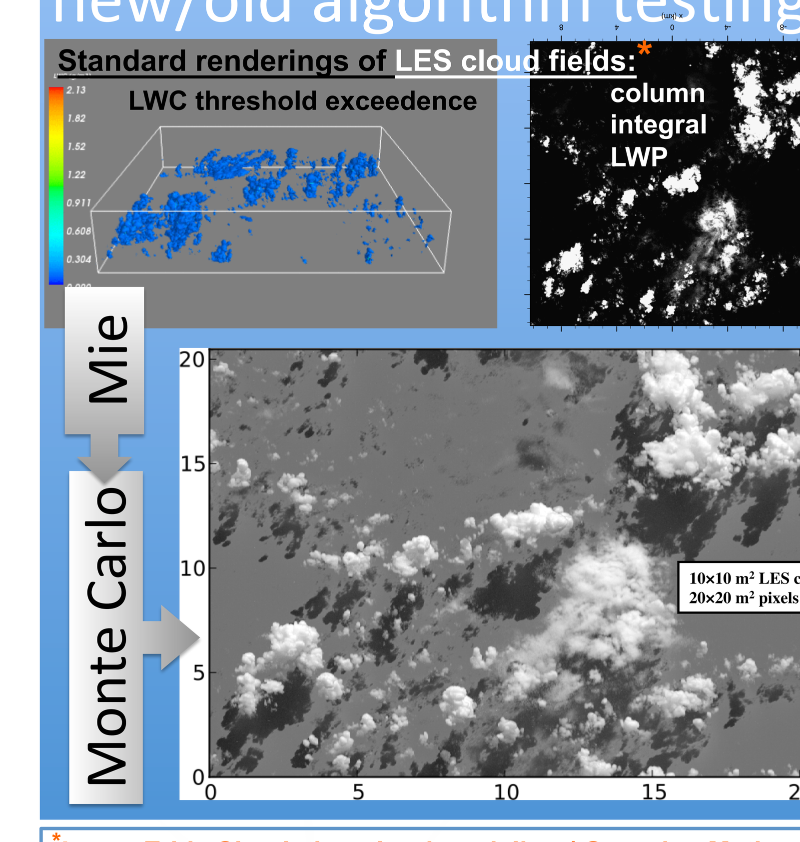
3a. Cloud outer shape reconstruction: Columbia's inverse radiosity method



3b. Cloud outer shape reconstruction, with opacity: JPL's approach



4. High-fidelity 3D vector radiative transfer on cloud scenes from the JPL LES model using vMYSTIC, for new/old algorithm testing



*Large-Eddy Simulation cloud modeling / Georgios Matheou

aerosols only ← TOMOGRAPHIES → single cloud

Poster presented at:

Joint 14th Conference on Atmospheric Radiation and 14th Conference on Cloud Physics and Anthony Slingo Symposium

Boston, Mass, 7-11 July 2014. (Special Session: Emerging Directions in Atmospheric Radiation)

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Earth Science Technology Office